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As to the contents of the first part of Professor Deussen's general history of philosophy we can be brief. After an introduction into the historical conditions of philosophical India, he discusses in the first part the old Vedic civilisation and religion. The origin of philosophy begins with the commencement of doubt, and leads to the first dawn of the idea of cosmic unity, to speculations on the origin of the world, and also to the seeking after the unknown God which aspiration manifests itself in the Prajâpati hymn and other religio-philosophical poetry. The second period is the age in which the Brahmanas were written, and we observe how in an evolutionary progress the Indian mind finds a solution of the world-problem first in the mythological idea of Prajâpati, then in the ritual conception of Brahman, and at last in the philosophical theory of the âtman. As Professor Deussen, the author of the *System of the Vedânta*, is one of the best authorities on the history of Indian thought, it would be bold to make any critical remarks, the more so as the presentation of the subject is at once clear and concise.[1] We have here, in about three hundred pages, the matured *résumé* of all that has been heretofore written on the subject by the author as well as by other Sanskrit scholars. We need not add that this great picture of the evolution of Indian thought is as grand as it is interesting, and will, aside from its connexion in the general history of philosophy, be welcome to many who desire to have an authoritative and precise presentation of the subject.

P. C.

DIE PRINZIPIEN DER MECHANIK. In neuem Zusammenhange dargestellt von *Heinrich Hertz*. Mit einem Vorworte von *H. von Helmholtz*. Leipsic : *J. A. Barth*. 1894. Pages, 312. Price, M. 12.

A melancholy interest attaches to this work. Its brilliant author who had little more than begun his scientific career, but in that beginning achieved so much, died shortly before its completion in his thirty-sixth year ; and not long afterwards, his master, Helmholtz, with whom his scientific and personal relations had been so intimate, and who supplied a preface to the book, that is not the least of its attractions, followed him. Hertz's *Mechanics* represents the fruits of the last three working years of his life, and he worked until its close. The first part of the performance had, on the author's death, already received its definitive form ; the second was completed in all essential points and was only waiting a final revision : this was left to Mr. Ph. Lenard, who fulfilled the task in accordance with the author's wishes.

In a charming Preface, filled with profound *aperçus* into the psychological genesis of scientific thought, Helmholtz sketches the career of Hertz, telling us what made him so peculiarly fitted for his task, what his education had been, and by what preliminary work he had been led to his celebrated electrical discoveries. We see here what a genial character his was, and shall find that the influences which shaped his career in the branch that made him famous also left their impress upon his thought as it is embodied in the work before us.

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[1] The problem of a proper transcription of names and terms is still unsolved. It would be a blessing if our Sanskrit scholars could at last come to an agreement on the subject. In Professor Deussen's transcription of Indian names, all masculine nouns end in *a*, all feminine nouns in *â*, and all neuters in *am*. This may be convenient for German readers, who have still to bother about the three genders, but the method is inconsistent, as in this way neuters appear in their nominative forms, while the words of masculine gender are transcribed in their stem-forms.

The present work is important mainly in two directions. First, as a *philosophical discussion* of the principles at the basis of theoretical mechanics; and, secondly, as an attempt to *new-model* logically and æsthetically those principles, as contradistinguished from the practical working-rules of the science, which, as they already serve their appointed purposes, are left untouched. Whatever shall be its ultimate fate as fulfilling the conditions required in the last-mentioned attempt, its significance in the first cannot be overrated. Hertz's philosophical introduction has all the marks of candor and sincerity which distinguished his earlier performances, and which he possesses in common with most great inquirers of the first rank. As Helmholtz says, we possess few records of the inner psychological history of science that are comparable with them. To this philosophical introduction, therefore,—and this is the only side on which Hertz claims originality,—we shall devote the chief space of this review, reserving only a few remarks for the mathematical and technical form of the new system. The philosophical assumptions at the basis of scientific method lie nearer to the heart of their work than many inquirers imagine; the very repudiation of metaphysical speculations, now so common in physical treatises, constitutes, itself, a metaphysical assumption demanding verification, and involves, expressed or not, a special philosophy.

But first a word with respect to influences. In all that relates to the formal complexion and mathematical execution of his plan, Hertz owes his first stimulus to Helmholtz. Next to Helmholtz the English influence is noticeable, and naturally, for under that influence his renowned electrical researches began. In the philosophical direction his views have been powerfully influenced by Prof. Ernst Mach; in a general way they lean toward the Kantian standpoint, though embodying features of various, and even opposed, schools.

The author begins by inquiring what are the criteria of sufficient or adequate knowledge. The fundamental object of all natural knowledge, he says, is to enable us to predict future events, with a view of controlling our conduct. The means by which we foretell futurity is present or previous knowledge. The method is this. We construct for ourselves inward images, pictures, or symbols of outward objects, so fashioned that the results that follow logically and necessarily from the images are in turn always images of the results flowing naturally and necessarily from the objects. This presupposes a determinate correspondence between nature and the mind, which experience teaches us exists. Having sketched out, or had given to us, such pictures, we can reproduce by them, just as we should by models, in a short period of time, events that in the outward world take long periods of time to happen in.

Now, that such pictures should fulfil their purposes what must be their attributes—what is required of them? Different pictures of the same object are possible. What gives to any one preference over any other? Hertz says, we should refuse *ab initio* to admit pictures which in any form involve contradictions against the laws of thought. In a word, our pictures should all be *logically* admissible. This is the first criterion, and we shall refer to it henceforward as self-consistency or *admissibility*.

Secondly, our pictures should be *correct*; their essential relations should accord with the relations of outward things. Thirdly, two self-consistent and correct pictures of the same outward object may differ with respect to *appropriateness*. That picture of the same object is the most appropriate, the most fit, which mimics the most essential features of the object. Where all are equally distinct, that picture is most fit which contains fewest superfluous features—which is simplest. But this last requirement is never ideally fulfilled.

With respect to the scientific or methodological presentment of the pictures, the requirements take a slightly different shape. Such a presentment must show distinctly what properties the pictures have been invested with to secure admissibility, what to secure correctness, and what to secure appropriateness. Only in such a way are we rendered perfect masters of our mental portrait gallery and enabled to change and improve it. For appropriateness sake, terms, definitions, abbreviations are added. This class includes all arbitrary features. The experiential elements constitute the aspect designated correctness. The attributes of rational thought supply the conditions of admissibility.

Whether a picture is admissible or not we can decide *a priori* once for all; whether a picture is correct or not, can be ascertained well enough with respect to present experience, but not for future experience; whether a picture is appropriate or not, can never be determined, at least unequivocally, but admits of wide differences of opinion. Only by slow, tentative quests is relative certainty to be reached on this head.

Such are the formal points of view from which Hertz proposes to estimate physical theories and their forms of enunciation, and from which he minutely examines the hitherto prevailing systems of mechanics with a view to establishing and justifying his own. Those systems, or pictures, are three.

The first picture is the common presentation of mechanics, as it is found in nearly all text-books. Its fundamental concepts are those of space, time, force, and mass. Powerful as this system is, and successful as its application has been, nevertheless, grave doubts as to its logical consistency, its admissibility, have arisen in the minds of philosophical inquirers. Differences of opinion have existed as to the mathematical certitude of many of its propositions. Such has been its unsatisfactory character, its intellectual uncomfortableness, that even its most useful and fundamental working concept, force, has been brought before the bar and the agnostic verdict rendered that its nature is mysterious.

Here Hertz interpolates a discussion, which is full of light. We often hear the question, What is the nature of electricity? But might we not just as well inquire, What is the nature of gold or of velocity? Is the one better known than the other? Whenever we ask such a question, we seek what cannot be given in words. The trouble here, according to Hertz, is, that at the mention of gold and velocity no relations are assigned that involve subtle and obscure self-contradictions; but in the case of force and electricity more relations have been grouped together than are perfectly compatible with one another. We have a dim presentiment of this, and our search for light is expressed in the obscure, unintelligible question above mentioned. The obscurity is well illustrated by reference to Newton's laws, where force, in the second law, has only one directional aspect, but in the third, two. Now this dissatisfaction, the author claims, is not to be removed by the discovering of new and complex relations, but by the lessening of the relations huddled together in the fundamental concepts. In other words, remove the self-contradictions and the question will answer itself.

What, now, is the upshot of all this? We have cast grave doubts upon the admissibility of the system; why does it always give useful and assured results? It must be, that the obscurities in question affect not the essential aspects of the mechanical picture, that is, do not consist of contradictions between the relations corresponding to the actual relations of the things; but relate to the unessential features, to that which we have mentally and adscititiously annexed to the materials supplied by nature. In a word, the faults are logical faults of form, not of contents. Here is where the new critical work is to be done, and it will consist in clearly stating and distinguishing what in our mechanical picture of the world is matter of intellectual necessity, what matter of experience, and what of arbitrary convention. The obscurity here gathered has pervaded the elements so thoroughly, as to establish the dogma of their eternal validity. Matter of *a priori*, intellectual necessity has been merged with matter of experience, and the conviction of universal certainty in time and space arising from the former has been transferred and predicated of the latter. All we can truly say, however, is that the correctness of the traditional mechanical picture is limited to actual, present experience.

The natural method, by which science has always grown up, is the reverse of the speculative, critical method by which it is sifted and clarified. In the natural process the mental pictures are first found to be appropriate, then are put to the test of their correctness, and only finally freed from logical self-contradictions. This explains why the common system of mechanics exhibits eminent appropriateness, as applied to the simple phenomena which it was originally invented to explain. But to-day we must consider it in connexion with the whole field of physical knowledge, if we are to judge of its appropriateness in its fullest sense, and with that in view must inquire, Is our picture perfectly *distinct*? Does it embrace every feature now discoverable in natural motions, and only such? We must answer, No. The system does not comprehend all the mooted aspects of the so-called elementary forces. Moreover, it not only includes natural motions, but comprises also such as are not natural. Plainly, a system which would exclude all or a part of the latter would be fitter, possess greater appropriateness, than the old.

Nor is the picture simple. Unessential features are included in it. Such are its forces, which in many cases are wholly unnecessary adjuncts, as in the case of the motion of the stars, where the dynamical relations have never been made the subject of actual experience. The remark applies also to molecular forces, and to chemical and to many electrical and magnetic effects.

The author next considers the form which mechanics has assumed in the last few decades, in which the notion of energy has almost entirely superseded the notion of force. This, the second picture of the mechanical principles, has never been portrayed in all its details; but its possibilities have been recognised, and it is extensively employed by all modern teachers. Its chief claim to excellence is the removal of the difficulties encompassing the notion of force. It employs only the mathematical concepts of space and time, and the physical concepts of mass and energy, the last assumed to be constant in quantity and indestructible. Initially only three elements are considered, space, mass, and energy. The element of time is introduced by means of some integral principle, say Hamilton's. This assumed, we require one empirical fundamental law only, which, though not simple in form, and difficult of immediate apprehension, yet enables us to predetermine absolutely the actual course of future mechanical events. No additional fundamental factors are employed. All the rest are deductive consequences, simplifications, or mere auxiliary terms, appropriate, but not necessary. To the latter class in this system belongs the notion of a force which is introduced merely as a definition, affecting not the correctness of the system, but only its fitness. Has this system advantages over the first, and what are they?

First, with respect to its fitness it is more distinct. It reproduces more of the peculiarities of natural motions than the first It comprehends more exhaustively the dynamic relations of rigid connexions which baffled the first system. It is superior also in simplicity, concerning itself less with things of which we know practically nothing. The old system, when confronted with broader physical problems, was constantly obliged to consider atoms and molecules, things very remote from conception and observation. The caprice which reigned in this field was exceedingly painful to thoughtful investigators. If the results were correct, the intermediate steps possessed no demonstrable real significance. The doctrine of energy circumvents these difficulties. It has its starting-point only in experience. Save energy in its few forms, no auxiliary constructions enter. Our predictions are strictly confinable to the known peculiarities of the material systems considered, and it is wholly unnecessary to cover over our knowledge of details with arbitrary and unessential hypotheses. Not only the final results, but all the steps in the deduction of them, may be considered as correct and having meaning. Such are the advantages of the system on this count.

When we come to the correctness and logical admissibility of the second picture matters are a little different. Often mathematically possible applications of the principle lead to physically false results. Still, all doubts that may be advanced on this subject affect only the appropriateness of the system, not its correctness. The real difficulties await us when we consider its logical admissibility. It is incumbent upon us here to assign the simple and immediate experiences by which the presence of a definite store of energy is established. This is assumed in the theory, not proved. Some physicists ascribe to energy the properties and significance of a substance, distributed throughout space. But its conception has, as yet, been put in no satisfactory nor ultimate form. The main difficulty in it is that this substance appears in two totally different shapes as kinetic and as potential energy. Kinetic energy is definable in familiar, intelligible terms. Potential energy needs new determinations, in fact, does not admit of determination, *as a substance*. It may be viewed negatively, which is contrary to all modes of conception of substance. This discussion is significant, and should be read by persons thinking along the lines of the school of Tait. Lastly, it is natural to expect that a fundamental law of mechanics should be simple. This the Hamiltonian principle is not, and no characterisation of this objection as metaphysical is admissible. The requirement of simplicity is not made of nature, but of our mental models of nature. It was these various objections that led Hertz to renounce the second system, which he at one time tried, for that which he afterwards developed and which is ranked and discussed in his introduction as the third. Of this, we are now in a position to see the drift and utility.

Hertz's own system starts from three concepts only, time, space, and mass. No fourth notion, such as force or energy, is admitted, at least as a fundamental conception. With these three notions alone, however, the resultant relations of the fundamental concepts are somewhat complex. Something seems to be wanting, and this is supplied by a hypothesis not here suggested for the first time. What it is, will be evident. When we attempt to understand the motions of bodies and to refer them to simple and lucid rules, taking into account only what we have palpably before our eyes, our attempts fail. The complexity of the events of the world is greater than that complexity which is within the reach of the senses. To come by a complete, detailed, and competent view of the world, we are obliged to imagine behind the things which we see, other *invisible* things, we are compelled to search behind the barriers of the senses for secret, hidden *accomplices*. The unseen factors here signalised were conceived in the first two systems as entities of a special sort, and were reproduced as them in the notions force and energy. But another way is open. We may admit that a hidden something is active here and yet deny that it can be subsumed under any definite category. We are at liberty to assume that the hidden factor is itself nothing but motion and mass, not different from molar motions and masses, but lying without the range of observation. This is the conception, or rather the hypothesis, by which Hertz fills the gap mentioned. In the pictorial imagination, to the visible masses of the universe are added other masses obeying the same laws, and by the mechanism thus conceived order is introduced into the universe and harmony into the perceiving mind. No other causes are admissible or necessary. Force and energy are now only *effects* of masses and motions of this lesser and more tenuous sort.

Such explanations are termed dynamical explanations. They explain visible effects by invisible effects of the same kind on a reduced, ultra-microscopical scale. Instead of regarding force and energy, those "secret accomplices" of natural events by which the imagination helps us to explain the world, as noumena, things of thought, abstractions merely, made for the purposes of mental reproduction, these invisible imaginary factors are conceived as the effects of the same sort of phenomena as they are invented to explain, only reduced in dimension. At what link in this descending chain of explanation is science to stop? Is it a whit less difficult to explain the motions and masses of very small, invisible particles in their complex effects as impacts, impulses, forces, energy, than it is to explain the same effects in larger, visible bodies? The whole tendency and search, unless it is properly qualified, has the marks of a metaphysical quest, and is unmistakably a departure from Kirchhoff's ideal, which is the direct quantitative expression of the relations of events, *unalloyed by any mental fictions whatsoever*. There is a note of warning on this point in Helmholtz's remark in the Preface. He says, referring to Thomson's and Maxwell's well-known theories of vortex atoms and electro-magnetic media: "Those inquirers were evidently sensible of a higher satisfaction in the theories mentioned than in the simple, very general expression of the facts and the laws given by systems of differential equations in physics. But I must confess that I, for my part, have found the most security in adhering to the last-mentioned mode of presentation, although I should not be disposed to raise objections touching points of principle against physicists so eminent as those mentioned."

Besides, in assuming that the hidden factors are masses in motion, has Hertz himself not "subsumed them under a special category"? The artifice is a natural one, and almost always employed; for we are eye-minded, and the most familiar part of our intellectual mastery of nature is written in the language of vision. But that part is scientifically perhaps not the most important and powerful part. Trigonometry accomplishes more by regarding infinite series as the definitions of sines and cosines than by adhering to the old, but easily visualised geometrical definitions. So it is with the law of evolution and with the principle of the conservation of energy.

Yet the method in question has been employed with the most fruitful consequences by the most eminent modern inquirers. Thermal forces have been explained by the hidden motions of sensible masses; and electro-dynamic forces and forces of elasticity, by similar assumptions. Now, says Hertz, if this hypothesis has gradually put mysterious forces out of mechanics, it has also a function to fulfil in preventing their original entrance into it—a function which accords with the whole methodological drift of modern physics. This is the critical idea from which he has proceeded in the development of the third picture. And now we may be brief.

First, we have the three independent and fundamental notions of time, space, and mass as simple objects of experience, because we can assign the actual concrete, sensuous facts by which they are determined. In the case of mass, along with sensually perceptible masses, others hidden and sensually inaccessible are introduced. The relations are then combined that control the union of these concrete experiences. Time and space are combined, and the result is kinematics. Mass and time do not enter into combinations. But mass and space are connected by significant and intimate relations. Between the masses of nature we find empirically definite, purely spatial connexions to exist, such that from the beginning until the end of time, and therefore independently of time, certain definite positions and definite changes of position are imposed upon those masses as possible positions, all others being impossible. Further, the connexions thus empirically exhibited relate only to the relative positions of the masses, and they satisfy definite conditions of continuity, which admit of precise mathematical expression. Finally, all three notions are combined, and the result is mechanics in the ordinary, restricted sense, as applied to material systems. Here a single fundamental law holds, the most general expression of their empirical connexion. This law is a joint product of the law of inertia and of Gauss's principle of least constraint. Expressed in ordinary terms, it asserts that, if the connexions of a given, independent material system could be dissolved for a moment, the masses of the system would disperse in rectilinear and uniform motion, but as such dissolution is not possible they persist as near as they possibly can to that conative motion. This is the fundamental and ultimate experiential principle of this system of mechanics. With the help of the hypothesis of hidden masses and law-ruled connexions, all the rest of the contents of mechanics are derived from it by pure deduction. Force enters the system not as something independent and foreign to us, but simply as an ancillary mathematical construction. In its present form, there is nothing mysterious about it. The same remark applies to energy.

The form and terminology of the system are new. What justifications in the way of utility and appropriateness exist for the alteration ? They are, first, its simplicity and brevity. In the new form, the mechanics of material systems does not appear as an extension and development of the mechanics of the single point, but the latter appears, as it should appear, simply as a special case. The new method conforms more to actual experience which begins not with the abstraction point, but with tangible, concrete systems. A second but not so essential advantage is that of its mathematical form; it summarises in one theorem both Newton's first law and Gauss's principle of least constraint, eliminating from the first what is superfluous, and from the second what is mystical. Thirdly, it throws much light on Hamilton's method of treating mechanical problems by means of characteristic functions, which has become an important collateral branch of mechanics.

Important, nay, almost sole emphasis, the author lays upon the logical consistency, *the admissibility*, of his system, Whether it is more appropriate, whether it will embrace all future experience, are minor considerations. The prime motive of its being sprang from that other aspect which was so obscured in the common system of presentation. The author is confident that only one objection of a general character imperils it. That objection concerns the nature of the rigid connexions assumed between the masses, and which is indispensable in the system.

With respect to its correctness, it explains correctly very many natural motions and reaches a little beyond the results of assured experience, thus bearing the character of a hypothesis as touching two important points—the limitation of possible connexions and the dynamical explanation of forces.

With respect to appropriateness, its advantages are confined wholly to the formal realm and do not relate to practice. For practical applications the old system will perhaps never be superseded.

As to the mathematical form of the system it, too, departs from tradition. At the outset, it considers systems of points instead of single points. The mathematical treatment resulting from this has a strange physiognomy, but offers in recompense for its novelty the advantages of simplicity, naturalness, and conciseness.

The body of the work is made up of two books. The first is on the *geometry and kinematics* of material systems; the second on the *mechanics* of material systems. In these two books the new system is empirically and mathematically elaborated, and all the traditional matter of mechanics shown to be involved in its logical consequences. T. J. McCormack.

IMMANENTE PHILOSOPHIE. By *Max Kauffmann.* Leipsic: Wilhelm Engelmann. 1893. Pp. 130.

The author defines the object of his work to be a summary portrayal of reality, a systematic description of the world, having for its chief feature the rigid exclusion of all hypothetic supplements to empirical occurrences. This involves a definition of reality and of empirical occurrences. The investigation of what is reality and what is knowledge was pursued in an earlier treatise of the author entitled *Fundamente der Erkenntnisstheorie und Wissenschaftslehre.* The definition of the concept of cognition there given excluded the possibility of metaphysical knowledge. It was held that under the notion of Knowable only the facts of consciousness fall, and that these were identical with the facts of empirical reality. It was attempted to show that causality, mathematical and logical laws are nothing else than relations of things appurtenant to empirical reality; and by a criticism of ontological proofs it was sought to establish the untenability of ontology, as also to prove that every world outside of the empirical world is, both in constitution and in existence, questionable, and consequently to be repudiated by sound theoretical philosophy. A synopsis of the arguments of the former work is given in the Preface as a foundation for the fabric of the "Immanent Philosophy" reared in the present work. Ac-